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SHORT COURSE ON

QUALITY FUNCTION DEPLOYMENT

FOR THE
U.S. SHIPBUILDING INDUSTRY

Prepared By

The University of Michigan Transportation Research Institute,
Marine Systems Division

For The

NATIONAL SHIPBUILDING RESEARCH PROGRAM

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16. Abstract

The stated objective of this project was to "provide research services for development of technology transfer for use of quality function deployment (QFD) in the shipbuilding industry." In support of this objective, UMTRI MSD (1) researched QFD teaching methods and applications in shipbuilding and other industries, (2) developed a short course/workshop for teaching QFD to the U.S. shipbuilding industry, (3) presented three QFD workshops for the U.S. shipbuilding industry, and (4) combined the Instructor's Manual, User's Manual, course overheads, and video tapes into a package that can be borrowed from the NSRP Documentation Center and used as the foundation for future presentations of QFD short courses/workshops.

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EXECUTIVE SUMMARY

Quality Function Deployment (QFD) is a powerful tool for customer-driven product and process development and organizational planning. Nearly all world-class manufacturing and service companies are using some form of QFD as a key part of the Total Quality Management business philosophy.

This repofi with the attached appendices, provides all of the textual course material and overhead slides necessary for the presentation of basic QFD training courses in the U.S. shipbuilding environment. Appendix A is the QFD *User's Manual* which serves as the basic text for the course, and as a general QFD reference guide. Appendix B is the QFD *Instructor's Manual* which is a copy of the *QFD User's Manual with* notes included for course instructors. Appendix C contains masters of all of the overhead slides associated with the QFD course, as called out in the *QFD Instructor's Manual. This* material is intended to be used in conjunction with five videotapes (NSRP Documentation Center reference: ED 91-95), produced by Technicomp, Inc., which can be rented from the National Shipbuilding Research Program (NSRP) Documentation Center at the University of Michigan (313-763-2465) or purchased directly from Technicomp.

This course material was developed spectilcally for the shipbuilding industry after extensive study of the QFD methodology as it has evolved and been applied in U.S. and foreign industries over the past two decades. Some of this course material has been borrowed with permission horn other organizations involved with teaching QFD to industry, including GOAL/QPC, which facilitated an initial QFD workshop at Portsmouth Naval Shipyard in May 1991. As part of this research project, the QFD course developed for the NSRP was presented once in Ann Arbor, Michigan, and once in Baltimore, Maryland. The course has also been presented at the Naval Sea Systems Command (NAVSEA) under separate NAVSEA funding. Shipbuilding-related organizations that were represented at at least one of these courses were Avondale Industries, Bath Iron Works, Hopeman Brothers, Ingalls Shipbuilding, National Steel and Shipbuilding Company, Newport News Shipbuilding, Peterson Builders, MarAd, NAVSEA, Pearl Harbor Naval Shipyard, Portsmouth Naval Shipyard, U.S. Coast Guard Curtis Bay Shipyard, and the U.S. Department of Defense.

Any organization wishing to use this material to present a QED course should utilize facilitators who are familiar with QFD and group dynamics, and who have thoroughly studied this course material and the associated videotapes. Any organization desiring assistance in organizing or facilitating a shipbuilding-related QFD course may wish to contact the University of Michigan Transportation Research Institute, Marine Systems Division, which developed this course material and facilitated the NSRP and NAVSEA courses associated with this project.

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Appendix A

QFD User's Manual

INTRODUCTION

As a result of U.S. shipbuilders' interest in Total Quality Management the National Shipbuilding Research Program's Education and Training Panel, SP-9, initiated the Quality Function Deployment (QFD) project to facilitate research in QFD and to provide shipbuilding-related education in innovative, customer-driven product planning and development.

This QFD material was developed and associated workshops were presented for the NSRP by the University of Michigan Transportation Research Institute, Marine Systems Division. The background research was conducted by Professor Howard Bunch, Project Director, and Mr. Mark Spicknall, Senior Engineering Research Associate. The User's Manual, Instructor's Manual, and case studies were initially developed by Mr. Spicknall and graduate research assistant Mr. John Senger. As a result of feedback from workshop participants, the manuals and case studies were revised by Professor Bunch, Mr. Spicknall, research scientist Roger Home, RAdm. U.S. Navy (ret.), and graduate research assistants Mr. David Amble and Mr. John Immink.

Some of the course material was developed directly fkom preexisting courses and texts on Quality Function Deployment. Sources of this preexisting material are

Technicomp, Inc., 1111 Chester Avenue, Cleveland, OH 44114-3516, (800/735-4440). Videotapes from Technicomp have been used with permission as one of the major features of the NSRP QFD course. A copy of these tapes can be rented from the NSRP Documentation Center along with an Instructor's Manual and a User's Manual. It is illegal to duplicate these videotapes. Anyone interested in purchasing a copy of the videotapes should contact Technicomp, Inc.

GOAL/QPC, 13 Branch Street, Methuen, MA 01844 (508/685-3900). GOAL/QPC facilitated a QFD workshop at Portsmouth Naval Shipyard to help initiate this project, and to assist Portsmouth Naval Shipyard in its quality improvement efforts. Several references are made in this manual to GOAL/QPC's "Matrix of Marnces" approach to QFD. Additionally, sections of the appendices are excerpts from the book, Better Desi m in Half the Time: Implementing Quality Function Deploymnent, by Bob King and published by GOAL/QPC in 1989.

Florida Power and Light (FP&L) - Quality Improvement Department, P.O. Box 14000, Juno Beach, FL 33408-0420, (305/552-4421). The primary project researchers atteneded a workshop presented by FP&L.

Prof. Yoji Akao, Tamagawa University, Japan. Prof. Akao's textbook, Quality Function Deployment. Integrating Customer Requirements Into Product Design, Productivity Press, 1990, was an important resource.

American Supplier Institute, Incorporated, Six Parklane Boulevard, Suite 411, Dearborn, MI 48216 (313/336-8877). The American Supplier Institute (ASI) has been conducting QFD workshops for over ten years, and is credited with introducing QFD to Ford Motor Company.

When material was used from these sources without modification in the NSRP manuals, overheads, and within the actual courses, permission was obtained from the appropriate sources.

These manuals and overheads, along with the associated videotapes, are intended to provide any shipbuilding-related organization with the tools necessary to conduct a course in the fundamentals of Quality Function Deployment. Several ship design- and construction-related case studies have been included for course participants or individuals to use in developing their QFD skills within a shipbuilding context. The following "PrOject Overview" provides a detailed description of the QFD course material.

Acknowledgments

The project team would like to thank Capt. Jay Smith, Mr. David McCarthy, Mr. Gene Foster, and Portsmouth Naval Shipyard (PNS) for hosting a QFD workshop to help initiate this project. Capt. Smith has been particularly helpful as a volunteer consultant to the project team. The team would also like to thank Dr. Jim Naughton of GOAL/QPC for facilitating the PNS workshop. The team would like to thank Mr. Steve Maguire of Avondale Industries, Mr. Jeff McCann and Mr. Mark Lasher of Bath Iron Works, Mr. Tom Rakish of Ingalls Shipbuilding, Mr. Thomas Thompson of National Steel and Shipbuilding, Mr. Leland Nelson of Peterson Builders, and Mr. Gerry Damon of Pearl Harbor Naval Shipyard for contributing to the project as representatives of the shipbuilding industry at the initial workshop.

PROJECT OVERVIEW

Definition of Quality Function Deployrnent

QFD is a disciplined planning process that facilitates the identification and deployment of customer wants and needs throughout a company as a basis for product planning, development, and implementation. QFD provides a system in which the voice of the customer drives product planning, product design, process planning, process control planning, production, sales, and service.

QFD is a key element of the Total Quality Management process, and is used in some form by virtually all world-class companies, including many successful commercial shipbuilders. In fact, QFD was first developed and used as a formal process at Mitsubishi's Kobe shipyard in 1972. QFD is credited with:

- enhancing internal and external communications,
- improving quality,
- increasing customer satisfaction,
- reducing product development time,
- lowering new product start-up costs,
- reducing the number of design changes,
- reducing warranty claims,
- fostering cross-function team building,
- facilitating simultaneous product and process design,
- improving design for production,
- allowing lower pricing as a result of lower development costs,
- removing bottlenecks in product development/implementation,
- building a database for future product development,
- providing a means of evaluating competition, and
- identifying key areas in product development where resources can be focused to gain competitive advantages.

General Format of the NSRP QFD Course

After attending other QFD courses and reviewing all available QFD references and texts, the project team decided on the following presentation format:

(1) General overview of the QFD process and its potential benefits.

(2) Detailed presentation of the Product Planning Matrix, or "House of Quality," including demonstration of the basic tools used to organize information for developing a matrix diagram.

(3) Basic group case study exercise on developing a Product Planning Matrix (with customer requirements already provided), including discussion of group dynamics and consensus decision making.

(4) Detailed presentation on obtaining and interpreting "the voice of the customer."

(5) Detailed case study exercises including interpreting the voice of the customer, developing and organizing customer requirements, and developing and interpreting the Product Planning Matrix.

(6) Detailed presentation of QFD project evolution and other QFD matrices.

(7) Continuation of detailed case study exercises with creation and analysis of other QFD matrices.

(8) Review of QFD fundamentals and other sources of QFD information.

Prior to developing this course's format, project team members and shipyard representatives attended other courses and workshops where the QFD process was presented chronologically; that is, methods of obtaining and interpreting the voice of the customer were presented first, followed by explanations of the Product Planning Matrix and other matrices. Project team members and shipyard representatives who attended some of these courses agreed that, without an overview of QFD and the Product Planning Matrix presented first, these courses lacked direction. Therefore, the NSRP course has been organized to provide an overview of the entire QFD process and of the Product Planning Matrix before presentation of material on obtaining and interpreting the voice of the customer. This format has proven to be successful, as participants in the QFD courses presented as part of this project have demonstrated a good general understanding of QFD by the end of the first day of the course.

Group Dynamics And The QFD Process

Group dynamics play an important role in the potential success of the QFD process. The process usually involves people with diverse backgrounds from many different areas and levels of an organization. When QFD is frost being tried by an organization, it is likely that many of the participants will be unfamiliar with each other and with other areas of the organization. It is absolutely critical that these participants overcome any parochialism that might exist so that they can work effectively as a team. Decisions made by team consensus during the QFD process are more likely to result in meaningful and useful organizational action. While there is no formal instruction provided in this course in the areas of group dynamics and consensus decision-making, there are some suggestions for managing group

dynamics provided in the course manuals at the beginning of Section V, Case Studies. For frost-time QFD implementation by an organization, it is recommended that facilitators be utilized who are familiar with team-building and consensus decision-making, as well as with QFD.

CONCLUSIONS

Quality Function Deployment has proven to be a valuable product planning and cross-functional management tool for world-class companies around the world. It is one of the key elements of Total Quality Management. QFD's primary strengths are that (1) it causes an organization to focus on customer requirements, needs, expectations, and desires as the basis for its products, services, and actions, and (2) it provides a mechanism that helps diverse interests within an organization communicate effectively. These strengths, in turn, facilitate teamwork and concurrent development of products and services that meet or exceed customer expectations.

It is likely that U.S. shipbuilders will have to use some form of QFD in order to compete successfully in the commercial shipbuilding market. The course material presented with this report, along with the videotapes available from the NSRP Documentation Center, can provide U.S. shipyards with the basic foundation required to begin using QFD.

Appendix B

QFD Instructor's Manual

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Appendix C

QFD Course Masters For Overhead Slides

Course Objectives

- **Introduce Quality Function Deployment to those associated with ship design and construction in the U.S.**

- **Give potential Quality Function Deployment users experience with the specific mechanics of the QFD process.**

- **Provide potential Quality Function Deployment users QFD** experience **within a shipbuilding context.**

- **Provide potential Quality Function Deployment users with additional references for QFD information and instruction.**

Definition Of QFD

- **QFD is a disciplined process that facilitates the identification and deployment of customer wants and needs throughout an organization as a basis for product planning, development, and implementation.**

- **A customer is anyone who uses your goods or services. Customers can be internal or external to your organization.**

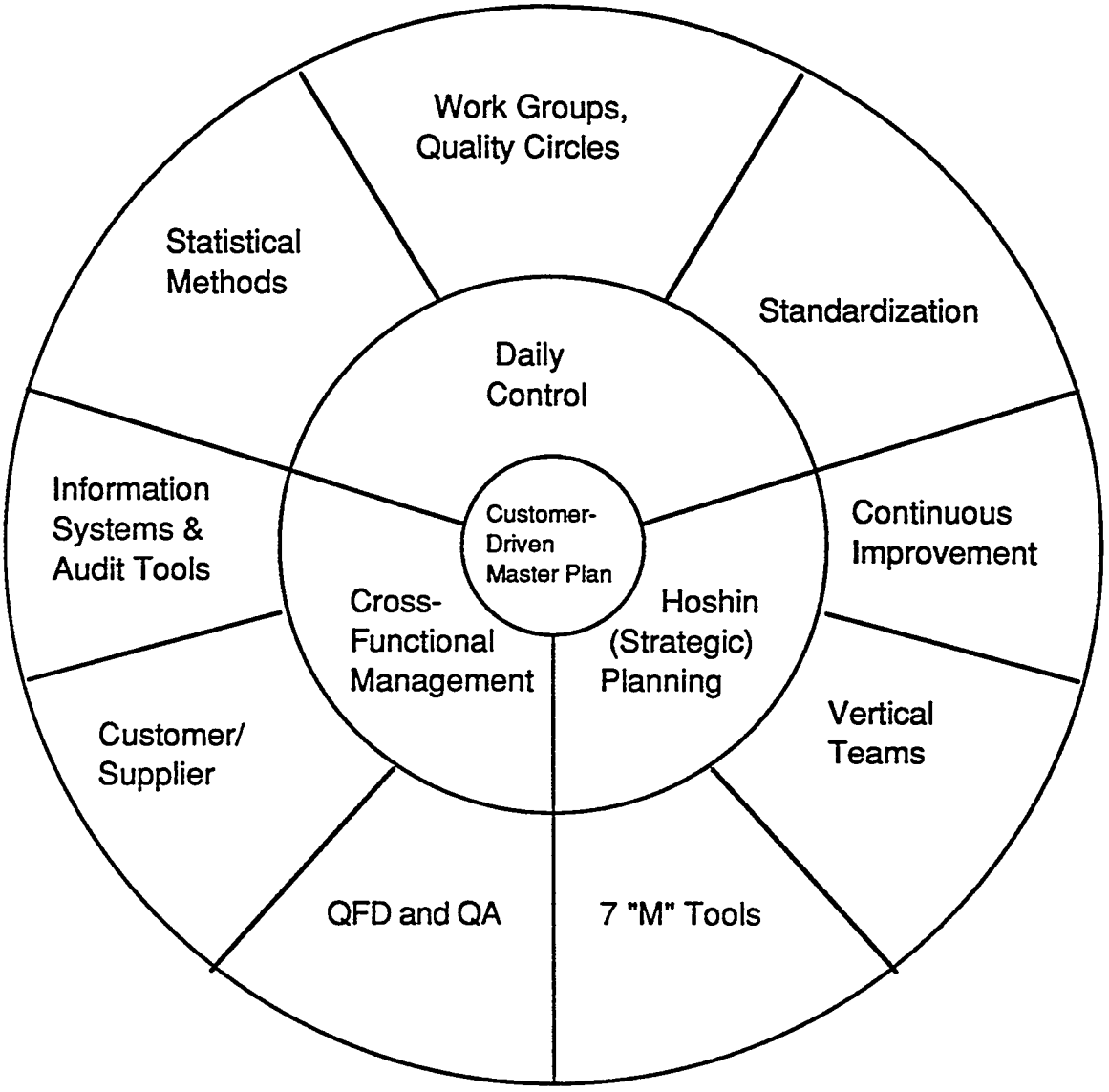
- **"Quality" does not just mean "conformance to specifications. " "Quality" in this context represents those attributes that customers want or need in a specific product or service. These attributes are often qualitative rather than quantitative.**

The History Of QFD

- **The QFD methodology was conceived and first used as a formal discipline at Kobe Shipyard of Mitsubishi Heavy Industries in 1972.**

- **QFD has been adopted by most world-class product and service suppliers as part of the Total Quality Management (TQM) philosophy.**

- **QFD was introduced to the U.S. in 1983. Some U.S. companies that have made QFD an integral part of doing business are Motorola, Ford, Rockwell International, IBM, and Florida Power and Light.**


Work Groups,
Quality Circles
Statistical
Methods
Standardization
Daily
Control
Information
Systems &
Audit Tools
Customer-
Driven
Master Plan
Continuous
Improvement
Cross-
Functional
Management
Hoshin
(Strategic)
Planning
Customer/
Supplier
Vertical
Teams
QFD and QA
7 "M" Tools

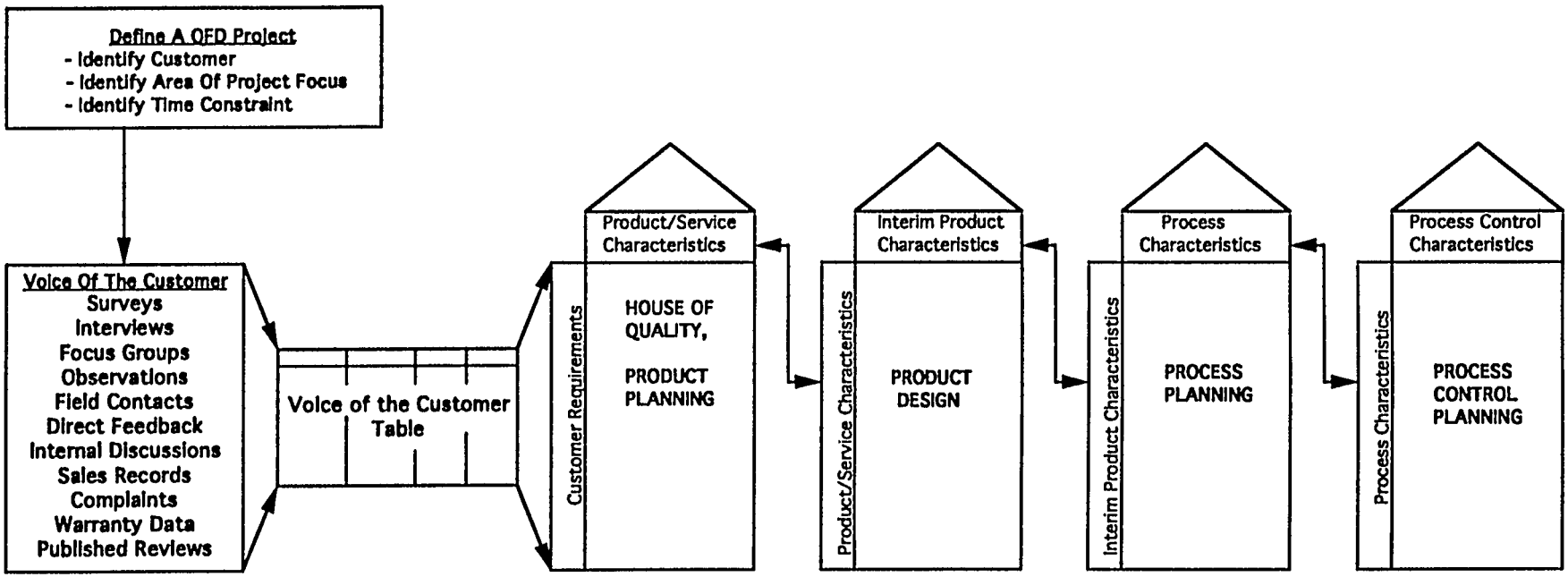
QFD Benefits

- **Enhances internal and external communications**
- **Improves quality**
- **Increases customer satisfaction.**
- **Reduces product development time by 30-50%**
- **Lowers start-up costs by 20-60%**
- **Reduces the number of design changes by 30-50%**
- **Reduces warranty claims by 20-50%**
- **Fosters cross-function team building**
- **Facilitates simultaneous product and process design**
- **Improves design for production**
- **Allows lower pricing because of lower development costs**
- **Removes bottlenecks in product development and implementation**
- **Builds a database for future product development**
- **Provides a means of evaluating your competition**
- **Identifies key areas in product development where time and effort can be focused to gain a competitive advantages**

TERMINOLOGY

- **House of Quality (generic)= Product Planning Matrix (generic)= A-1 Matrix (GOAL/QPC)**
- **Customer Requirements (NSRP)= Quality Requirements (Florida Power and Light, FP&L)= Demanded Quality (Akao and GOAL/QPC)= Required Quality (American Supplier Institute, ASI)**
- **Product/Service Characteristics (NSRP)= Technical Requirements (Technicomp)= Quality Elements (FP&L)= Quality Characteristics (Akao and GOAL/QPC)= Quality Items (ASI)**
- **Interim Product/Part Characteristics (NSRP)= Part Characteristics (Technicomp)= Mechanisms and Unit Parts (Akao)= Systems and Unit Parts (ASI)= Mechanisms, Systems, Sub-Systems, Parts, Components, Raw Material (GOAL/QPC)**
- **Process Control Characteristics (NSRP)= Process Control Methods (Technicomp)**

Underlined terminology will be used in this course.

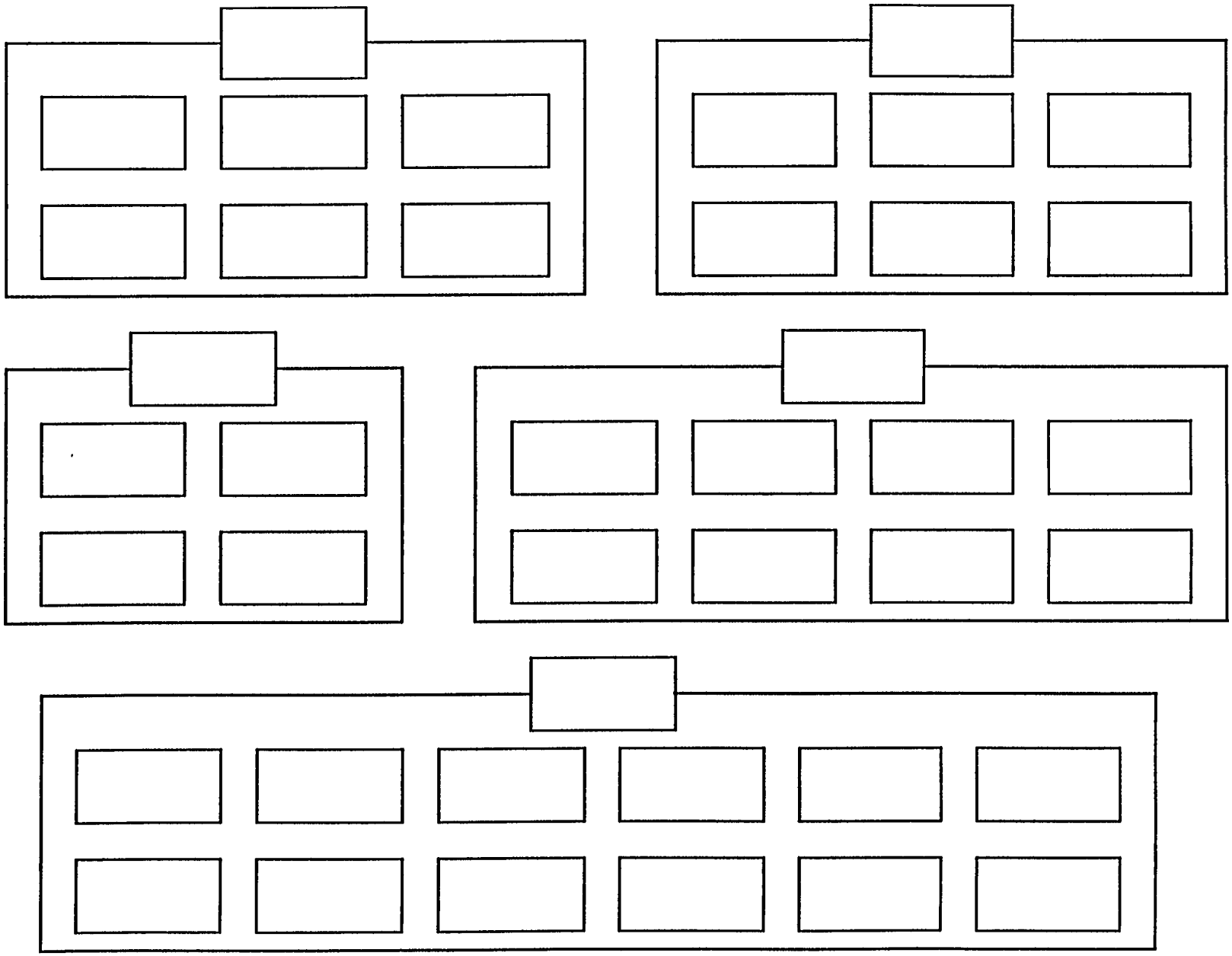


The Four-Matrix QFD Process.

Requirements For QFD Success

- Management commitment for at least a QFD pilot project is a minimum requirement.
- Active support and participation of management is ideal.
- Project team diversity is essential. The team may include members from:
  - Design/Engineering
  - Process Engineering
  - Production Engineering
  - Production
  - Quality Assurance
  - Marketing
  - Sales

  Depending on the type of QFD project, the team might also include:
  - Purchasing
  - Distribution
  - Accounting
  - Finance
  - Human Resources
  - Suppliers
  - Customers
- Project team members must have a basic understanding of QFD and must be committed to the QFD process.



Affinity Diagram.

Affinity Example

Customer (mechanic) requirements for a shipbuilding work package:

- **Bill of material**
- **Any special tools required**
- **Complete work sketches**
- **Definition of global reference lines to be used**
- **All material for production of the interim product**
- **All necessary production control documentation**
- **Accurate pieces**
- **Accurate list of material**
- **All pieces with proper ID**
- **All necessary inspection documentation**
- **Accurate work instructions**
- **Proper reference lines or marks on all pieces**

Work sketches without unneeded information

Affinity Example

Correct Parts

Ž All material for production of the interim product

• Accurate pieces

. All pieces with proper ID

. Proper reference lines or marks on all pieces

Correct Bill of Material

• Accurate list of material

• Any special tools required

Correct Instructions and Sketches

• Complete work sketches

Ž Definition of global reference lines to be used

• Accurate work instructions

• Work sketches without unneeded information

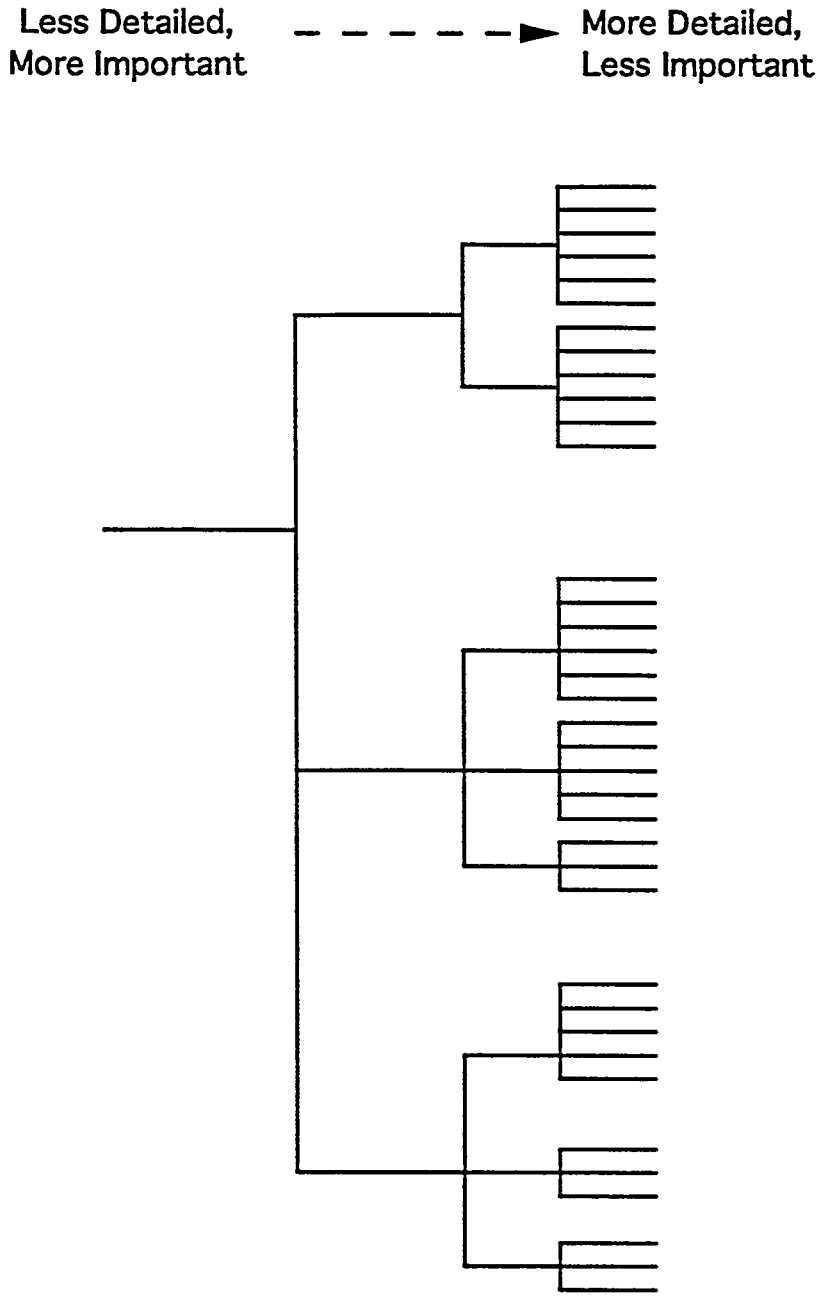
Correct Work Documentation

• All necessary production control documentation

• All necessary inspection documentation

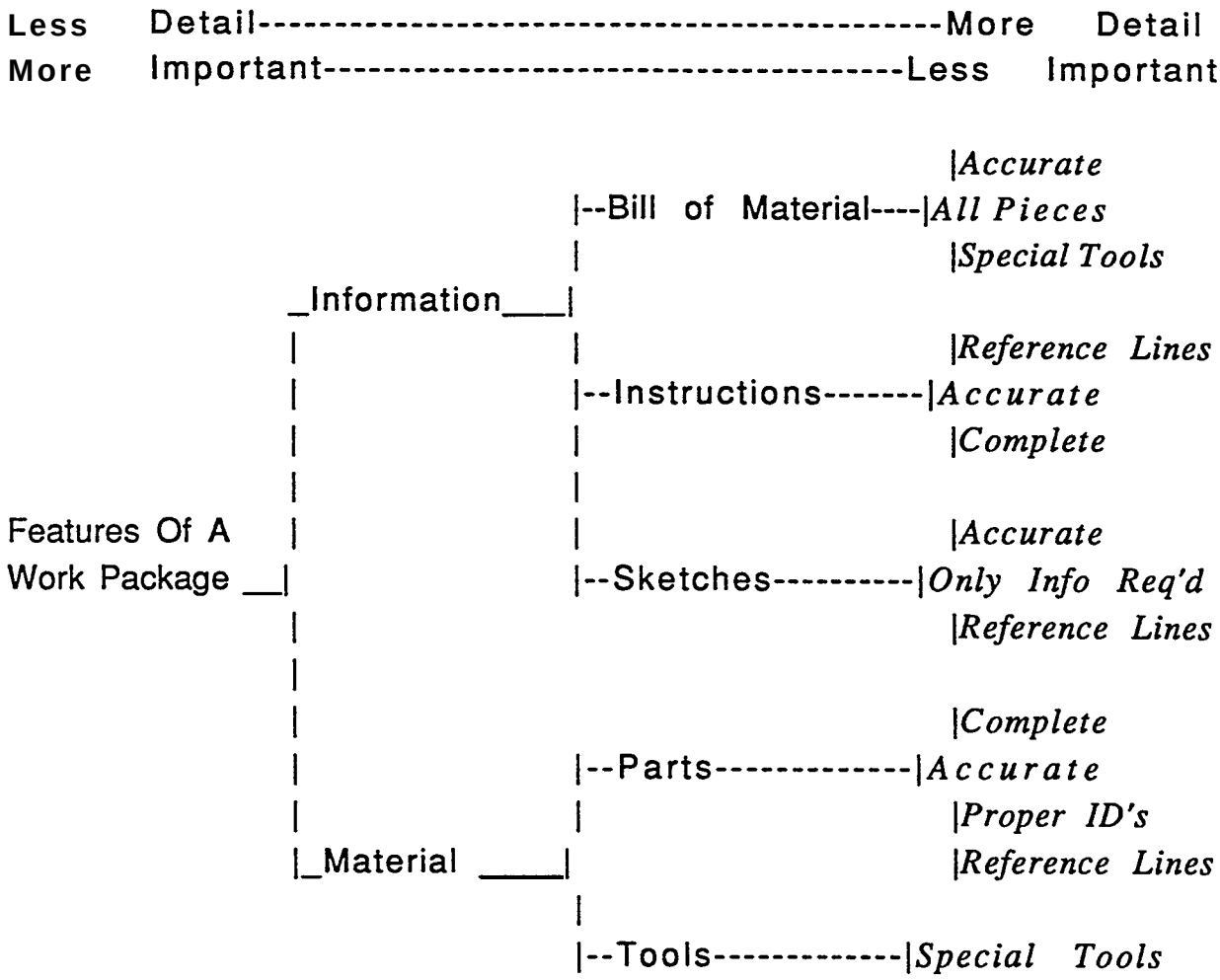
Correct Tools

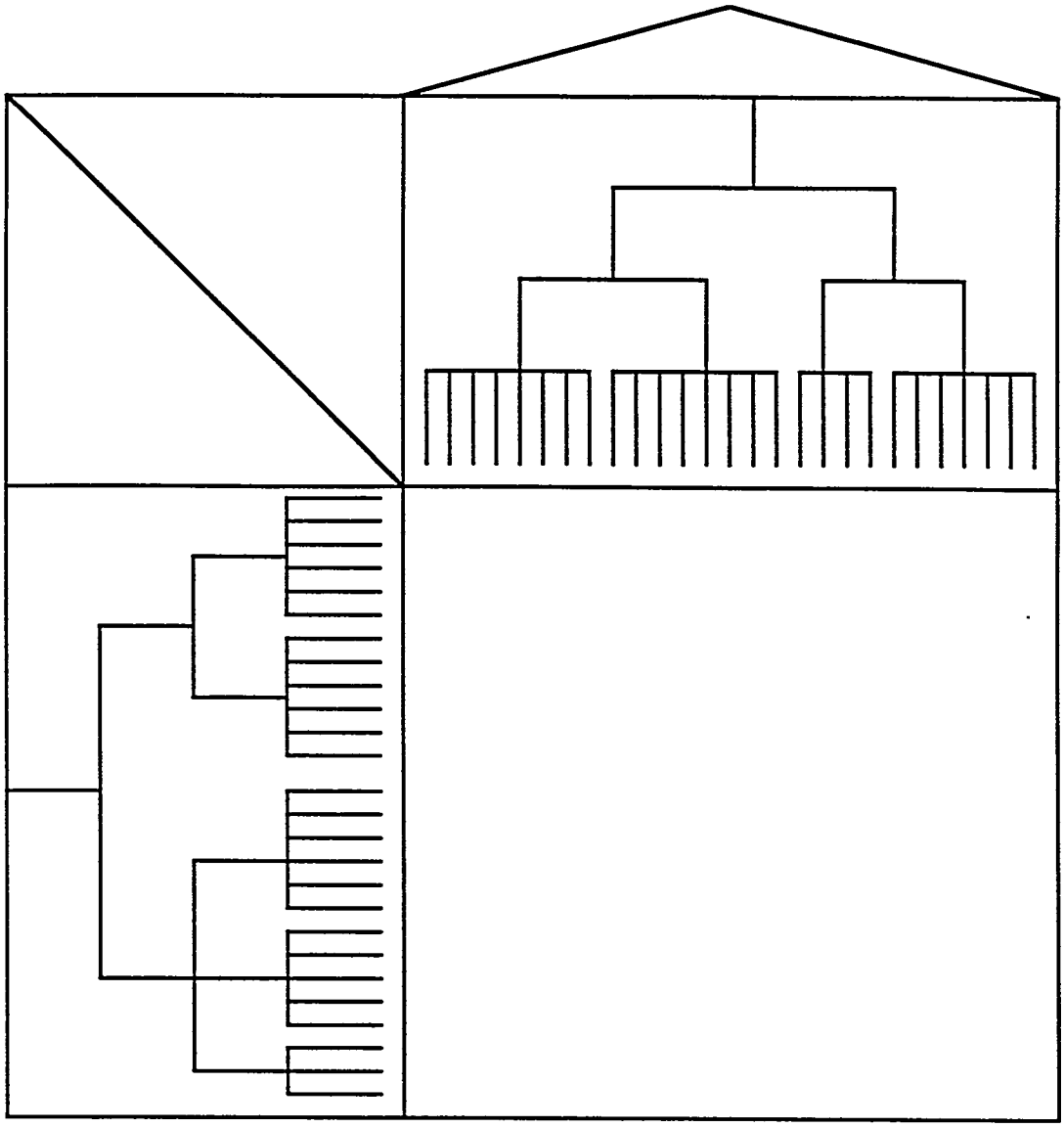
• Any special tools required



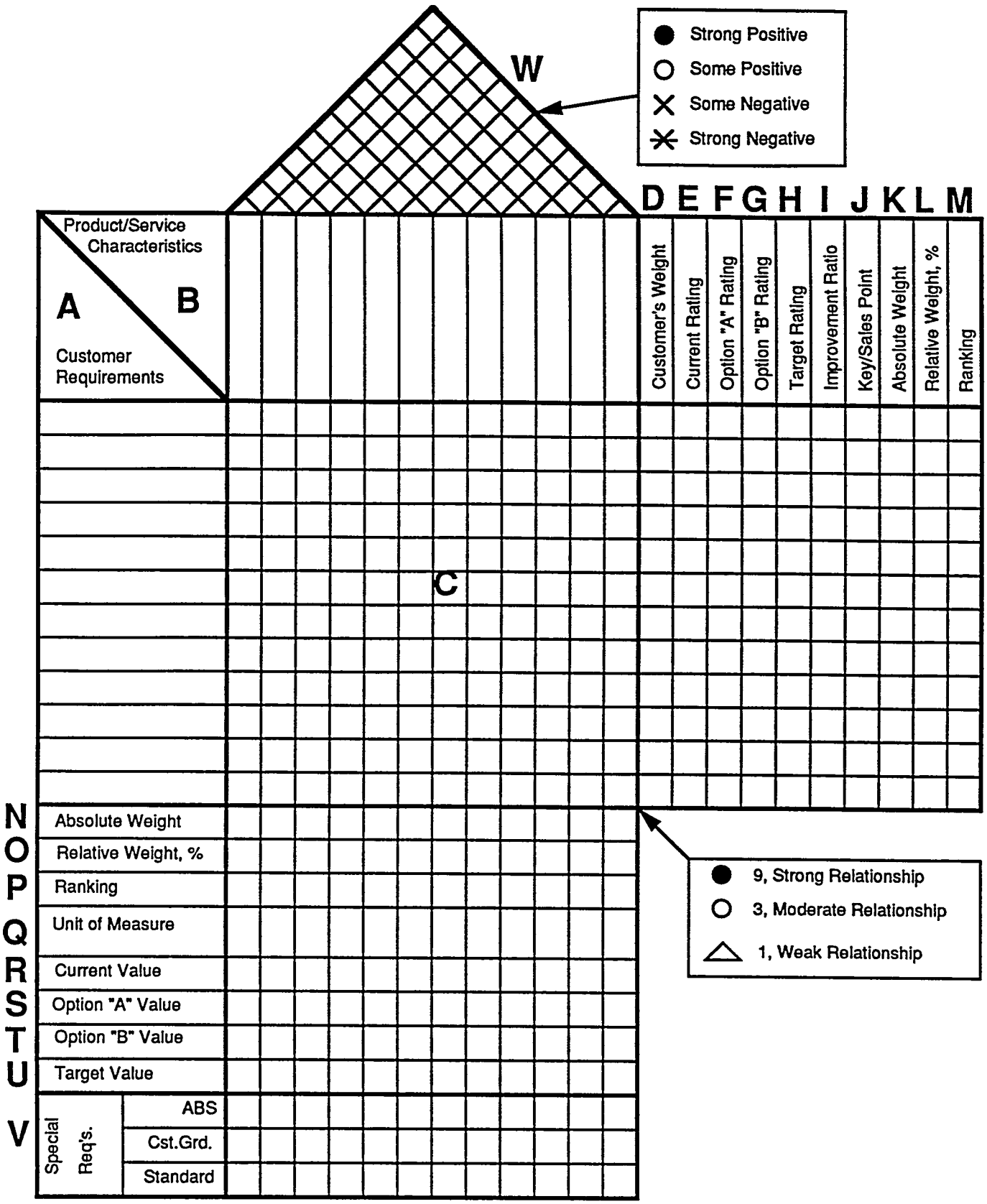
Tree Diagram.

Example Tree Diagram

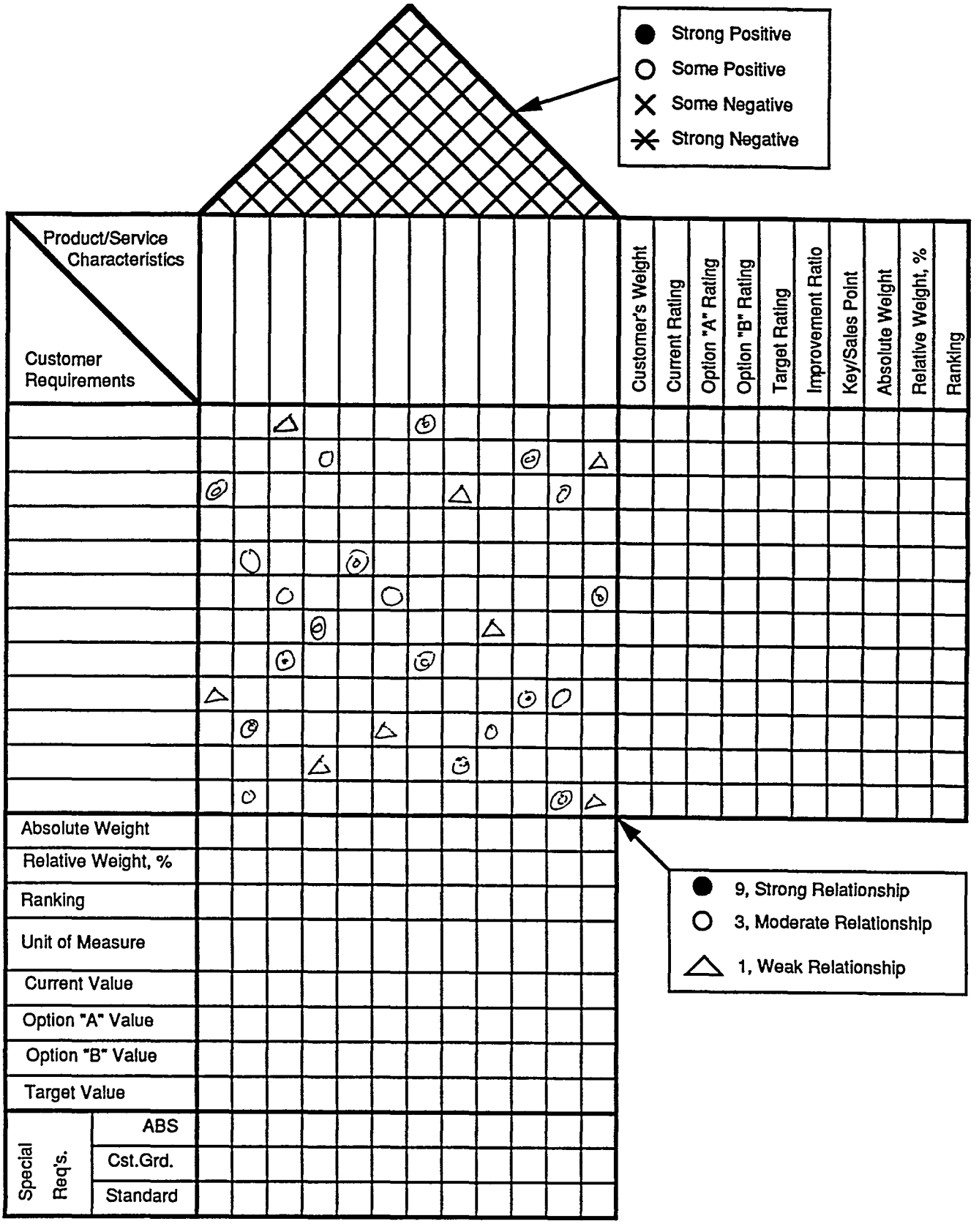




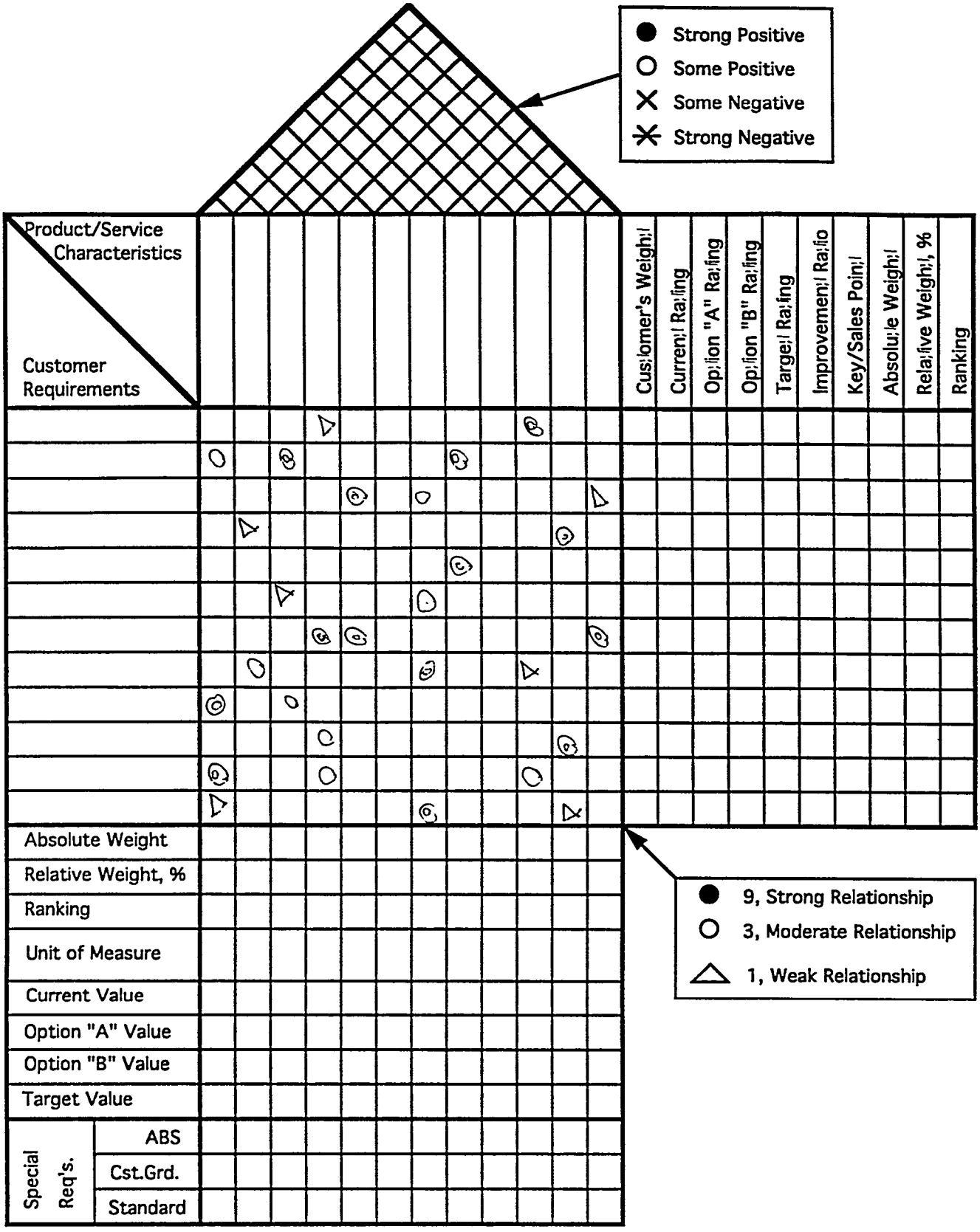
Tree Diagrams Related To A QFD Matrix.



House Of Quality/ Product Planning Reference Matrix.



The House Of Quality/Product Planning Matrix.



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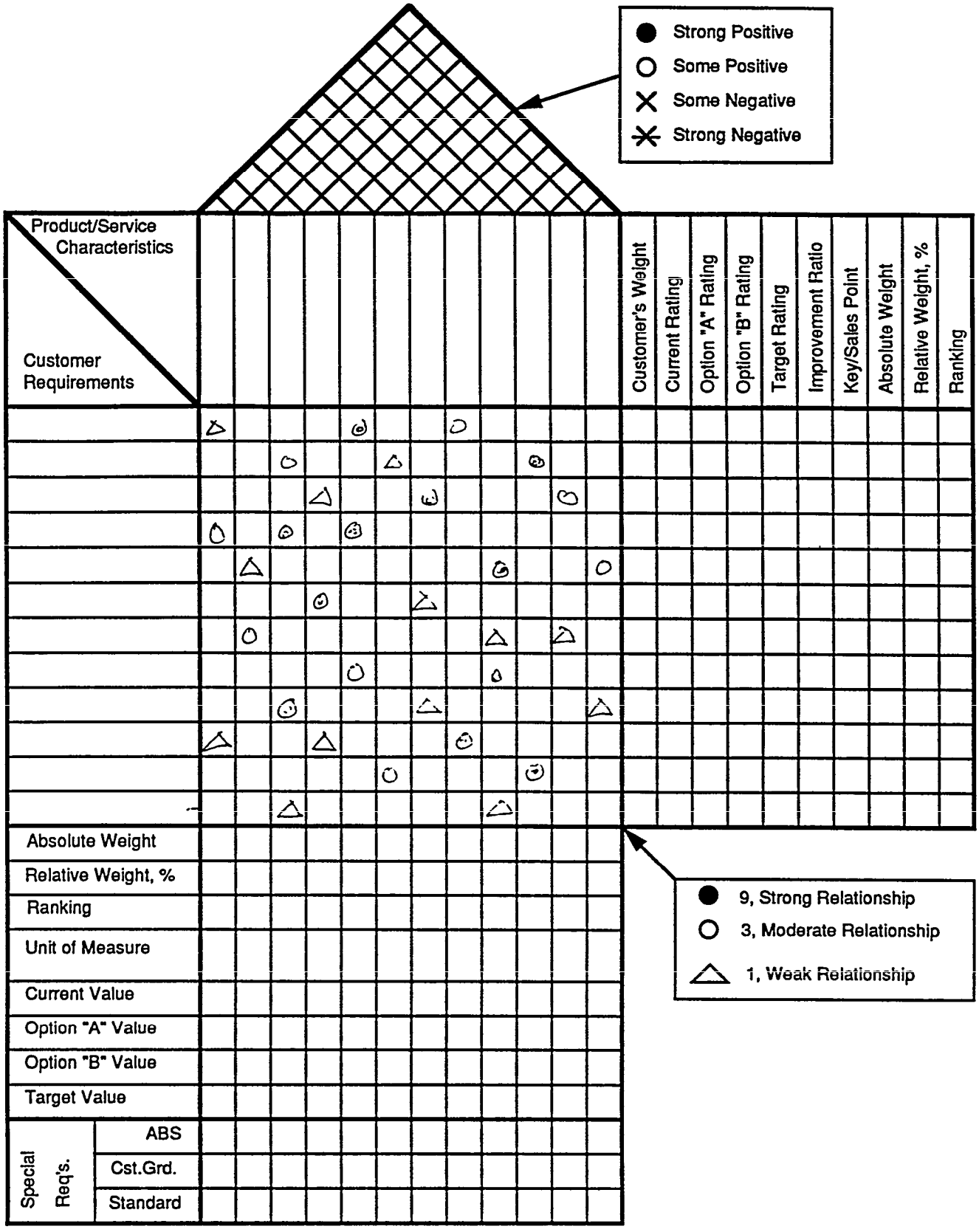

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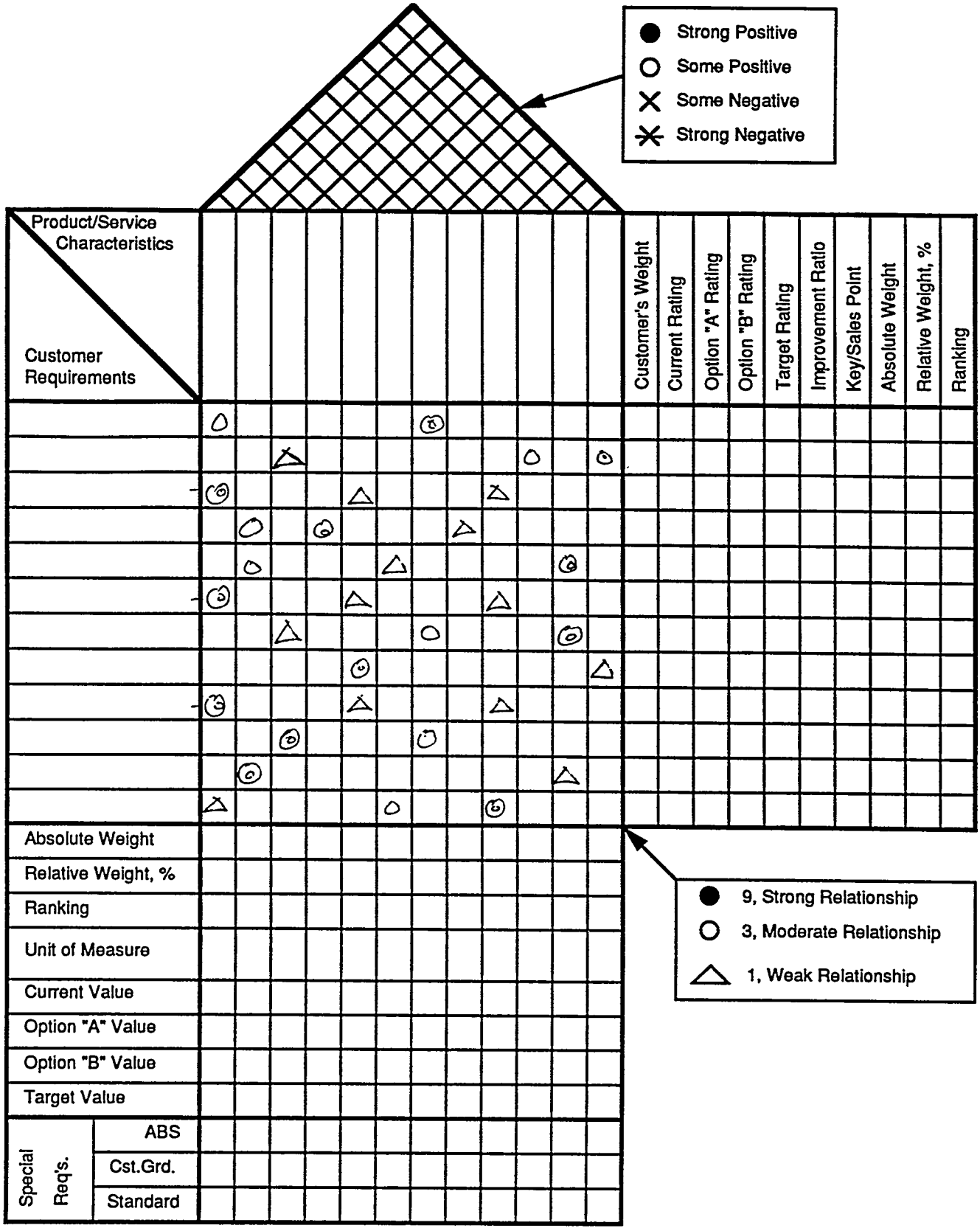

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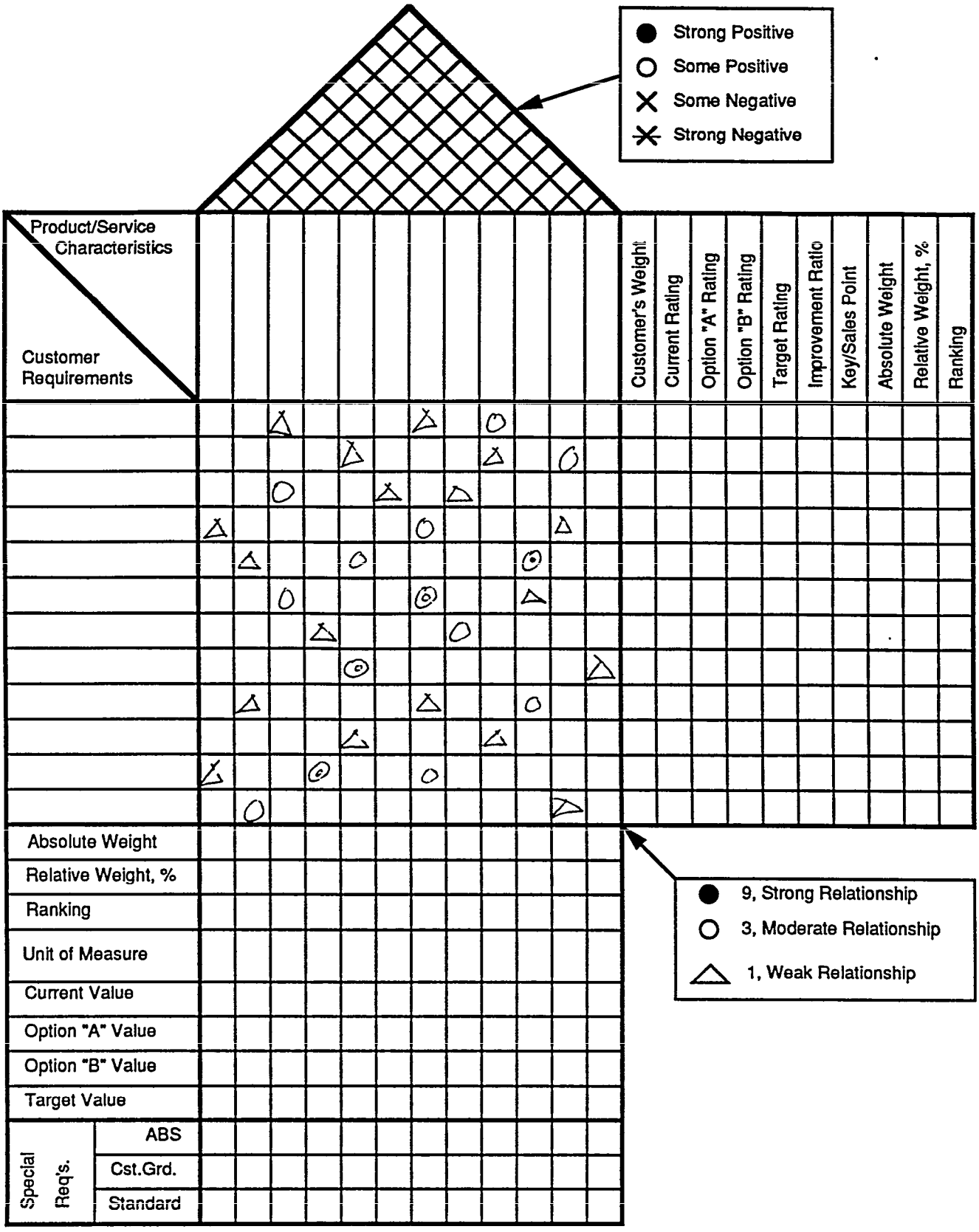

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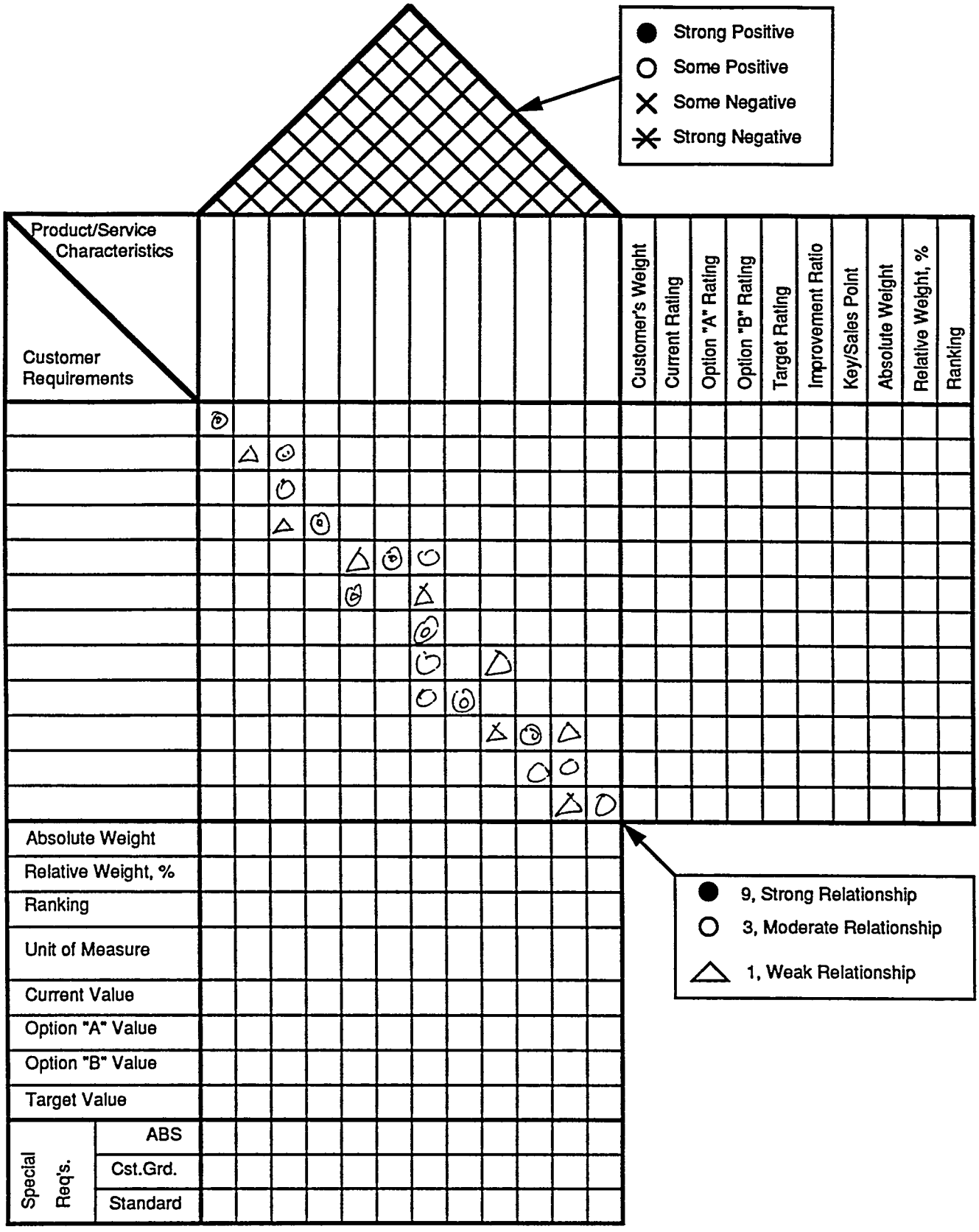

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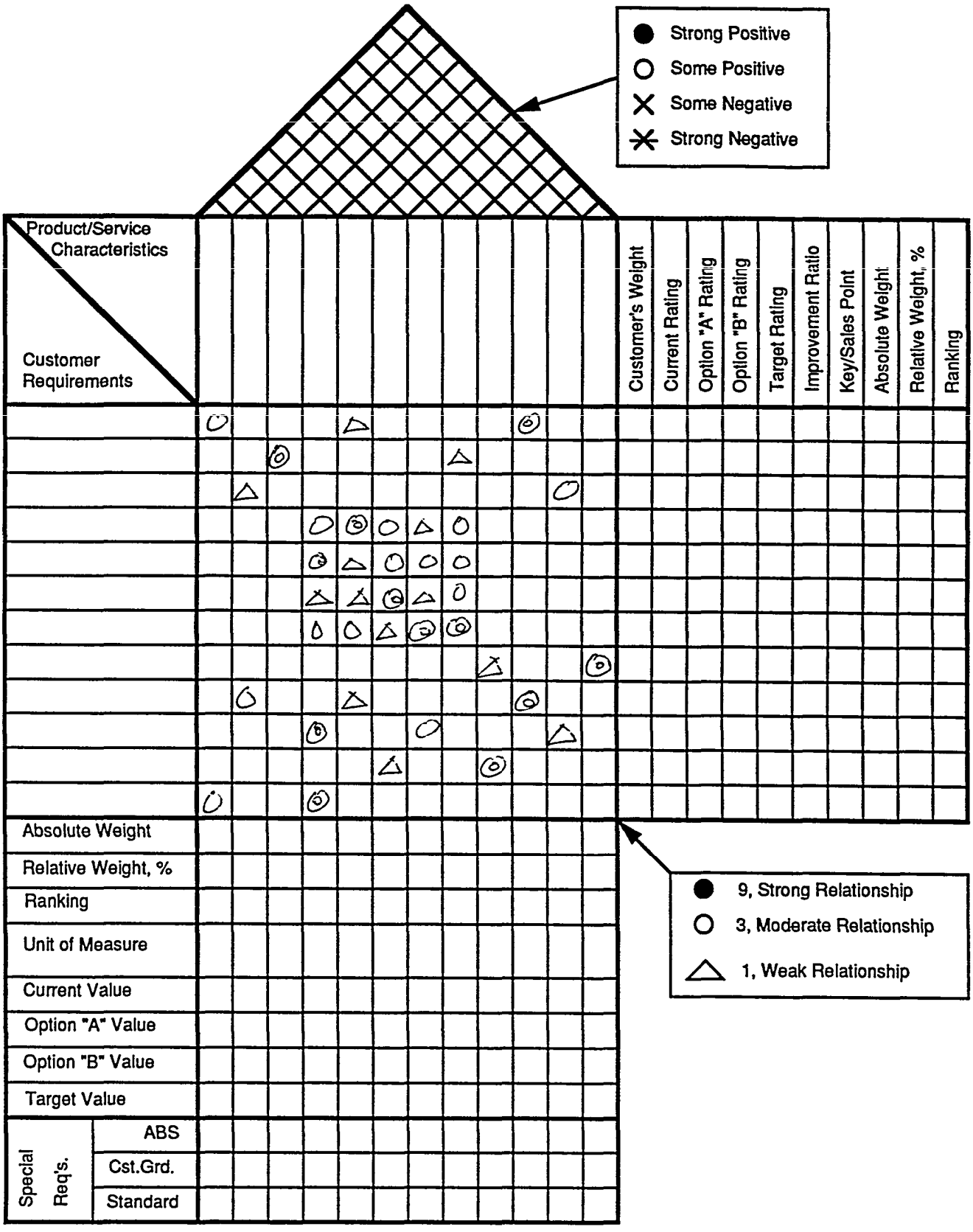

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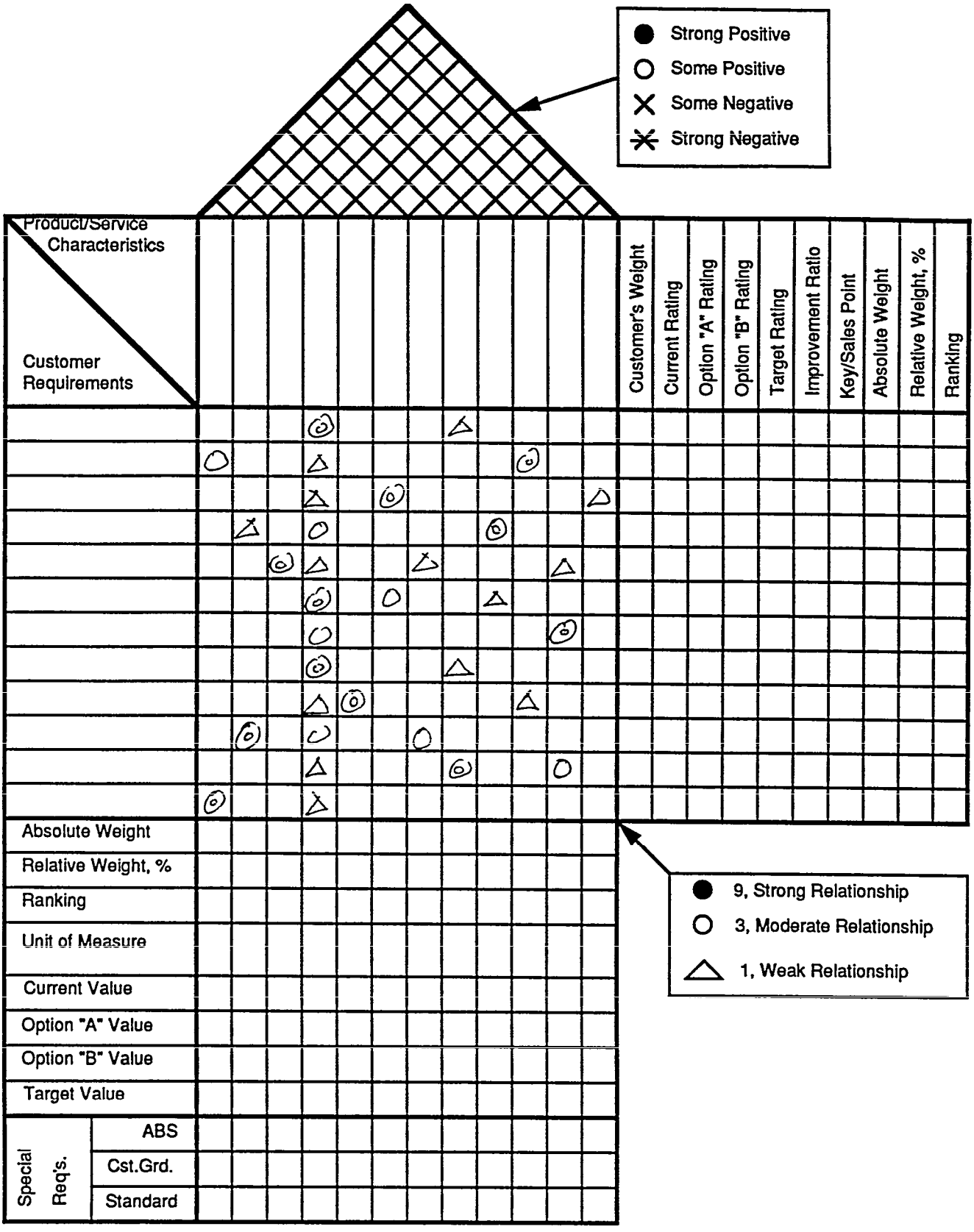

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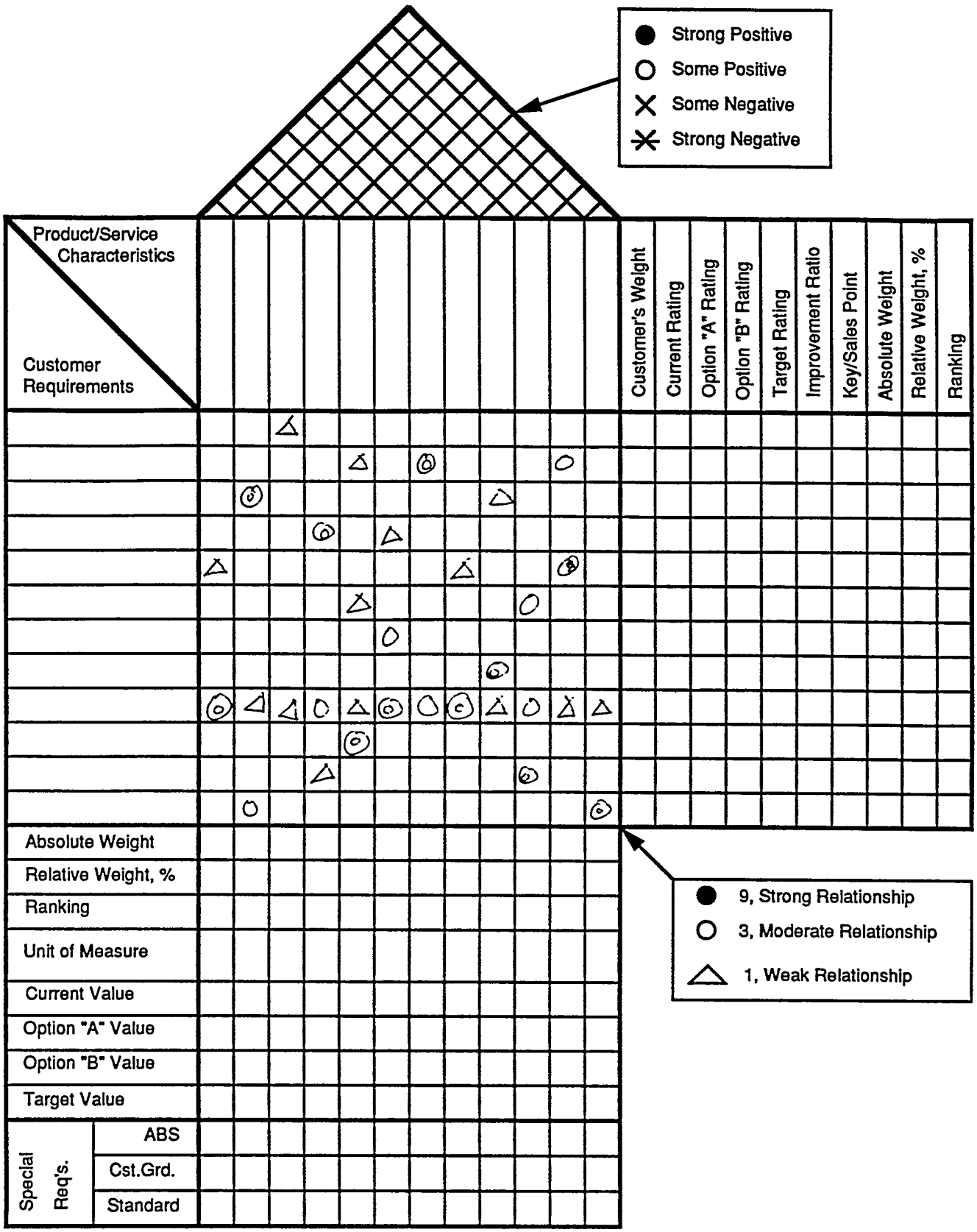

The House Of Quality/Product Planning Matrix.

Having completed a House Of Quality, you should have:

- a very good idea of the relative importance of specific customer requirements and associated product or service characteristics,

- identified areas where a competitive advantage might be gained, and where compromises might have to be made in product development, and

- developed target values for product/service characteristics, and methods for measuring whether these requirements are being met.

Perceptions Of "Quality"

- **One-Dimensional Quality: Features that customers specifically request. If these features are present, customers are pleased. If these features are absent, customers are not satisfied.**

- **Expected Quality: Features that are considered essential and, therefore, are often taken for granted and not specifically requested. If these features are present, customers are satisfied. If these features are absent, customers are not satisfied.**

- **Exciting Quality: Features that customers do not realize are possible. They may relate to new technology. Because customers do not realize that these features are possible, they do not specifically request them. If these features are present, customers are surprised and very pleased. If these features are absent, customers are not unsatisfied.**

Voice Of The Customer Sources

	Information	Complexity	Sample	Bias	Time	Cost
INTERVIEWS						
Face to Face	Direct	Medium	Small	No	High	High
Telephone	Direct	Medium	Small	No	High	High
FOCUS GROUPS	Direct	High	Small	No	High	High
OBSERVATIONS						
Clinics	Direct	High	Small	No	High	High
Displays	Direct	High	Small	No	High	High
FIELD CONTACTS						
Sales Meetings	Direct	Low	Small	Yes	Low	Low
Service Calls	Direct	Low	Small	Yes	Low	Low
Trade Shows	Direct	High	Medium	Yes	High	High
DIRECT VISITS	Direct	High	Medium	Yes	High	Medium
EMPLOYEE FEEDBACK	Direct	High	Medium	Yes	High	Medium
SURVEYS						
Mail	Indirect	Medium	Large	Yes	High	High
Telephone	Direct	Medium	Medium	Yes	High	High
Comment Cards	Indirect	Medium	Large	Yes	High	Low
Point of Purchase	Indirect	Medium	Large	Yes	High	Low
SALES RECORDS						
Monthly Sales	Indirect	Low	Large	Yes	Low	Low
Sales Contacts	Indirect	Low	Large	Yes	Low	Low
Replacement	Indirect	Low	Large	Yes	Low	Low
Part Sales	Indirect	Low	Large	Yes	Low	Low
COMPLAINTS						
Letters	Direct	Low	Large	Yes	Low	Low
Cards	Direct	Low	Large	Yes	Low	Low
WARRANTY DATA						
Service Records	Direct	Low	Large	Yes	Low	Low
Service Workers	Direct	Low	Large	Yes	Low	Low
Return Cards	Direct	Low	Large	Yes	Low	Low
TOLL-FREE HOTLINE	Direct	Low	Large	Yes	High	High
PUBLICATIONS						
Government	Indirect	Low	Large	Yes	Low	Low
Independent	Indirect	Low	Large	Yes	Low	Low
Trade Journals	Indirect	Low	Large	Yes	Low	Low
Consumer	Indirect	Low	Large	Yes	Low	Low

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Demographics	Voice of the Customer	Contextual Info.	Reworded Statement	Customer Requirement	Function	Reliability	Misc.

Voice Of The Customer Table.

Once a VOCT has been completed, the project team should have:

- **a list of specific, singular customer requirements that are traceable back to specific voice of the customer statements;**
- **a mutual understanding of these customer requirements;**

Ž captured customer-provided information that can be referenced in creating other QFD matrices, such as functions and failure modes.

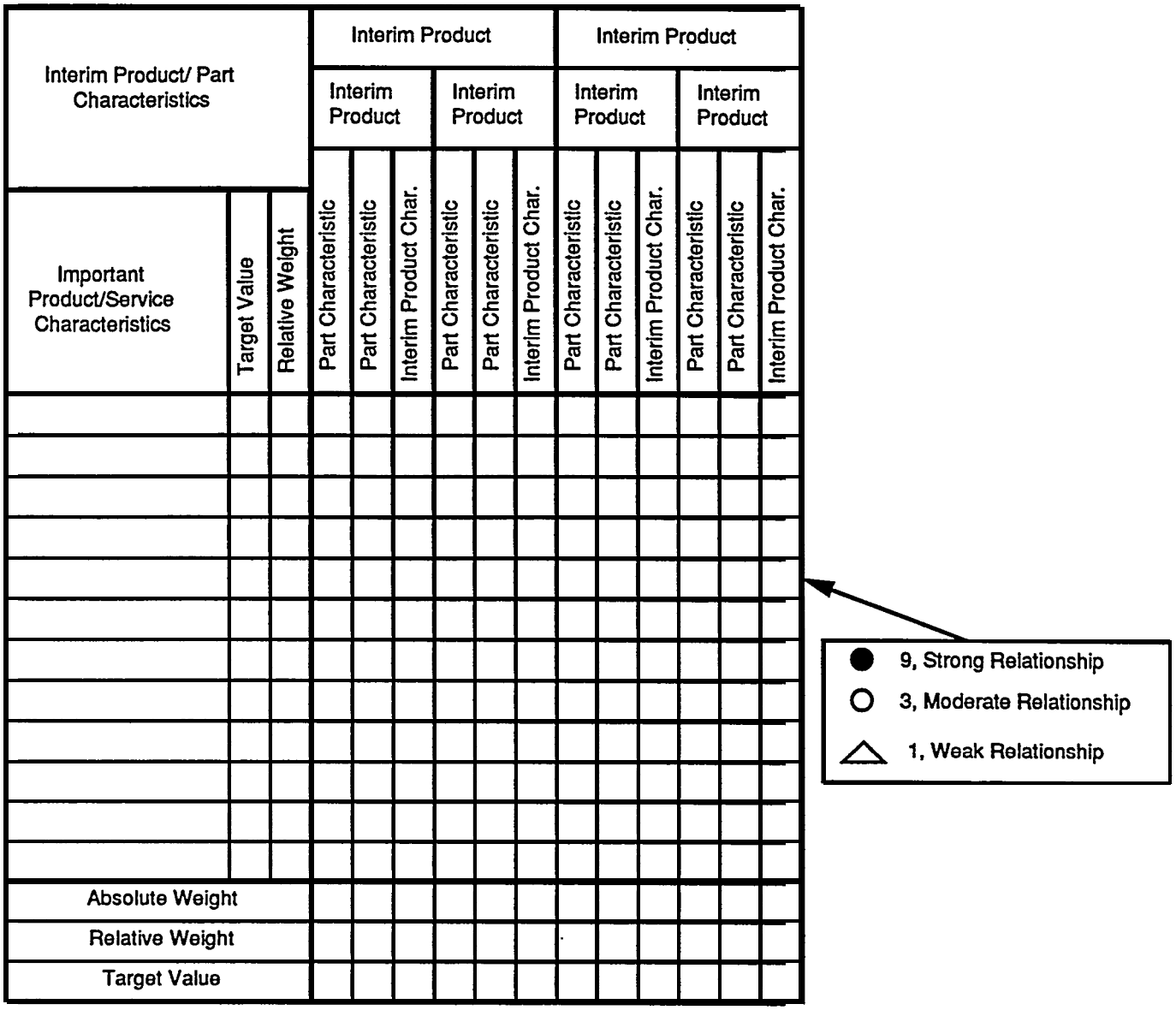
The customer requirements identified can now be used as the basis for an affinity diagram, a tree diagram, and, finally, the customer requirement axis of the product planning matrix.

When Is A OFD Project Complete?

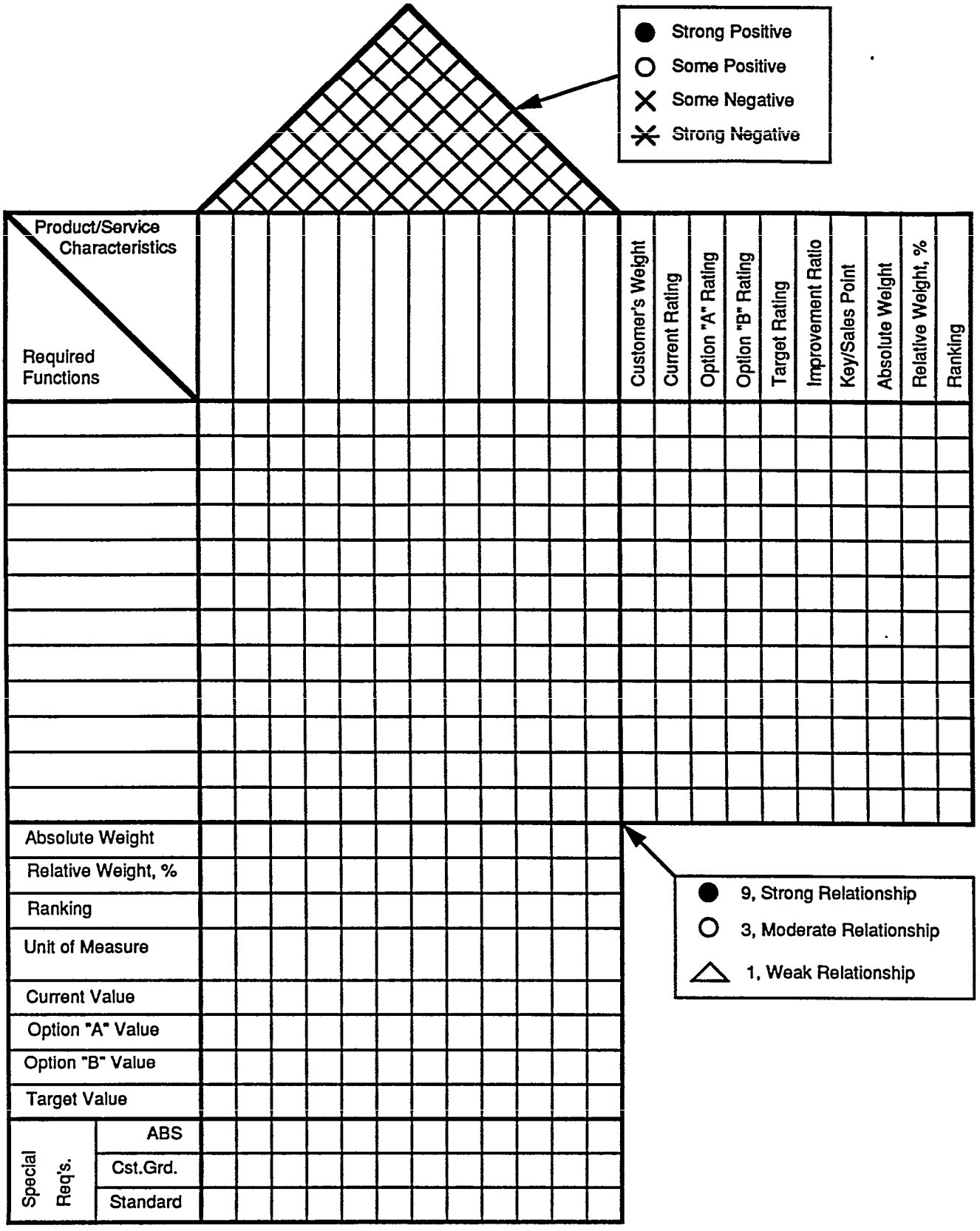
Having completed the product planning matrix, the project team will have:

- **gained significant understanding of what the customer wants,**
- **improved communication with the customer and within the supplier organization,**
- **established which product/service characteristics are important to meeting customer requirements,**
- **gained improved understanding of how well their product/service and the products/services of their competitors meet the needs of the customer, and**
- **identified areas where improvement in product/service characteristics could have a significant effect on customer satisfaction, sales, and competitiveness.**

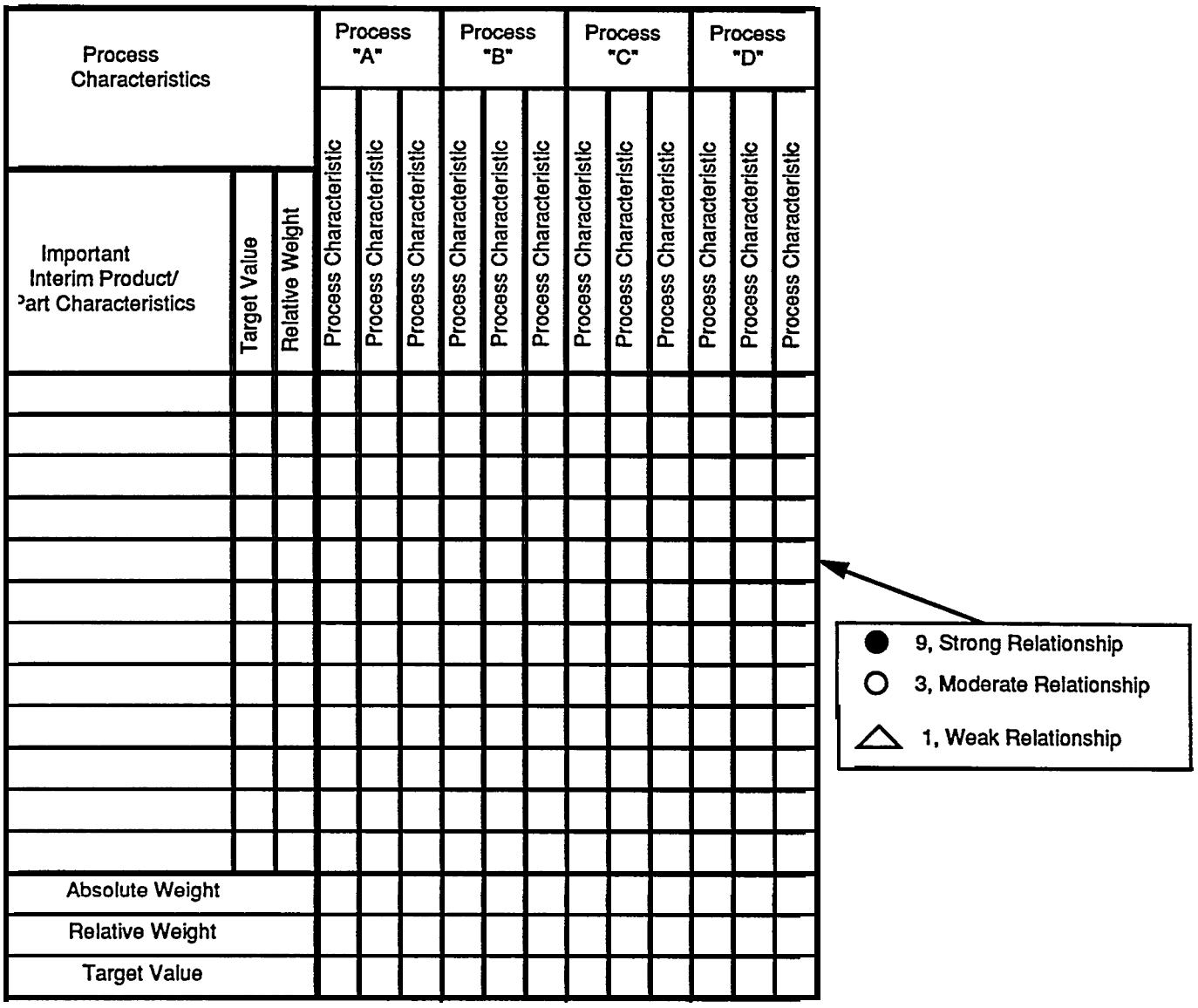
However, the project team may feel that additional detail is required in some areas, and/or that a detailed implementation plan is required to help translate customer demands into specific supplier organization actions.



The Product Design Matrix.



The Function Analysis Matrix.



The Process Planning Matrix.

Part/Interim Product ID	Process Function	Potential Failur Mode	Potential Effects	Potential Causes	Frequency	Degree of Influence	Criticality	How Detected	Suggested Countermeasure	Results

Failure Mode Effects Analysis.

Interim Product/Part ID	Interim Product/Part Characteristic Target Values	Process Identification	Process Characteristic Target Values	Planning		Process Control			Inspection			Required Tools		Personnel	Notes
				Training	Maintenance	Sampling Method	Sample Frequency	Analysis Method	Inspection Method	Inspect Frequency	Analysis Method	Type	Calibration		

Process Control Planning Matrix.